HOUSATONIC RIVER FLOOD CONTROL

DERBY, CONN.

LOCAL PROTECTION

HOUSATONIC & NAUGATUCK RIVERS, CONNECTICUT

DESIGN MEMORANDUM NO.3

HYDRAULIC ANALYSIS AND RIPRAP DESIGN

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

APRIL 1968

14

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

IN REPLY REFER TO:

NEDED-H

18 April 1968

SUBJECT: Derby Local Protection Project, Housatonic and Naugatuck Rivers, Connecticut, Design Memorandum No. 3 - Hydraulic Analysis and Riprap Design

Chief of Engineers
ATTN: ENGCW-E

There is submitted herewith for review and approval Design Memorandum No. 3, Hydraulic Analysis and Riprap Design for Derby Local Protection Project, Housatonic River Basin, in accordance with EM 1110-2-1150.

FOR THE DIVISION ENGINEER:

John Wm Leslie
JOHN WM. LESLIE
Chief, Engineering Division

1 Incl
as (5 cys)

DESIGN MEMORANDA INDEX

No.	Title	Date Submitted	Date Approved
1	Hydrology and Interior Drainage	10 Jan. 1968	14 Mar. 1968
2	General (Including Site Geology and Concrete Materials)	28 Feb. 1968	
3	Hydraulic Analysis		
4	Embankments, Foundations and Channel Improvements		
5	Structures and Pumping Station		

DERBY LOCAL PROTECTION PROJECT
HOUSATONIC AND NAUGATUCK RIVERS
CONNECTICUT

DESIGN MEMORANDUM NO. 3

HYDRAULIC ANALYSIS AND
RIPRAP DESIGN

LIST OF TABLES

LIST OF PLATES

DERBY LOCAL PROTECTION PROJECT
HOUSATONIC AND NAUGATUCK RIVERS
CONNECTICUT

DESIGN MEMORANDUM NO. 3

HYDRAULIC ANALYSIS AND
RIPRAP DESIGN

1. INTRODUCTION

a. Purpose. The purpose of this memorandum is to present for review and approval the hydraulic analysis and riprap design for the local protection project on the Housatonic and Naugatuck Rivers in Derby, Connecticut. Included are sections describing the project design floods, model study, hydraulic analyses and the design of the stone riprap for dike protection.

b. Background. The Derby Local Protection Project was authorized in Public Law 89-298, dated 27 October 1965 just 3 years following authorization of the Ansonia-Derby Local Protection Project. As the two are structurally integral the same general hydraulic criteria apply to both projects.

c. Coordination with local authorities. The general design has been developed with the knowledge and concurrence of the officials of the city of Derby who will be furnished copies of all design memoranda for use, comment and retention.

2. PROJECT DESIGN FLOODS

a. General. The Derby local protection project is designed for the standard project floods in the Housatonic and Naugatuck Rivers with a tailwater elevation at the confluence produced by the peak concurrent flow of the two rivers combined with an abnormal tide. Allowance for abnormal tide is about 2 feet which was experienced in the floods of September 1938 and October 1955. Development of the design floods is discussed in approved Design Memorandum No. 1, "Hydrology and Interior Drainage," dated January 1968.

b. Housatonic River. The dikes and walls adjacent to the Housatonic River are designed for a flow of 198,500 cfs in the Housatonic River with a concurrent flow of 21,500 cfs in the Naugatuck River for a total at the confluence of 220,000 cfs.

c. Naugatuck River. The dike adjacent to the Naugatuck River is designed for the standard project flood of 75,000 cfs in the Naugatuck River with a concurrent flow in the Housatonic River of 145,000 cfs, for a total at the confluence of 220,000 cfs.

3. HYDRAULIC MODEL STUDIES

a. General. Due to the complex flow conditions resulting from the irregularity and configuration of the channel sections and skewed bridges for which hydraulic losses could not be reliably computed, a hydraulic model of both the Derby and Ansonia-Derby projects was constructed to a scale of 1 to 120 at the U. S. Army Waterways Experiment Station, Vicksburg, Mississippi.

The model was constructed to reproduce the Housatonic River from the mouth of the Naugatuck River to Bridge Street in Derby, a distance of 3,800 feet, and the Naugatuck River from its mouth to the Anaconda American Brass Company hydroplant, a distance of 16,000 feet. Water was supplied to the model at the upstream ends simulating the flows of the two rivers and a movable tailgate was provided at the lower end to reproduce the desired tailwater and tide effects. A detailed description and layout of the model will be shown in Appendix A, entitled: "Hydraulic Model Study, Ansonia-Derby and Derby Local Protection Projects," to be forwarded at a later date.

b. Simulated floods. Tests were run in the model simulating design floodflows with normal and abnormal tide conditions in Long Island Sound. The following conditions of riverflow and tailwater were tested:

(1) Concurrent discharges of 21,500 cfs in the Naugatuck River, 198,500 cfs in the Housatonic River and elevations of 24.0 and 26.0 feet msl, respectively, at the confluence.

(2) Concurrent discharges of 75,000 cfs in the Naugatuck River, 145,000 cfs in the Housatonic River and tailwater elevations of 24.0 and 26.0 feet msl, respectively, at the confluence.

c. Alternate plans tested. In addition to model testing the plan of protection as proposed, the following alternate plans were studied:

(1) The Naugatuck River dike was moved riverward, maintaining a minimum channel bottom width of 160 feet and tested with a flow of 75,000 cfs in the Naugatuck River, 145,000 cfs in the Housatonic River and a tailwater elevation of 26.0 feet msl. The result was an increase in water surface elevation from zero at the confluence to a maximum of 1.3 feet at the upstream end of the Derby project. This increase in the water surface elevation at the upstream end of the Derby project was reflected in the profile of the Ansonia-Derby project upstream to the NYNH&H railroad bridge. It was therefore concluded that the small saving in land area accomplished by reducing channel width did not justify the added cost to both the Derby and upstream Ansonia-Derby projects.

(2) A model floodwall was placed on the west bank of the Housatonic River opposite Derby to determine what effect, if any,

future protective measures in the city of Shelton, Connecticut might have on the design Housatonic River profile. This plan was tested with a flow of 198,500 cfs in the Housatonic River, 75,000 cfs in the Naugatuck River with a tailwater elevation of 26.0 feet msl. The result was a negligible effect in the water surface profile along the proposed Derby protective works. Actually there was a small reduction in water surface elevations throughout the reach along the dike and floodwall in Derby and Shelton due to the improved streamlining of the flow on the Shelton side of the river.

(3) The trusses on the railroad bridge across the Housatonic were made solid to simulate their being clogged with debris. The water surface immediately upstream from the bridge was raised about 1.0 foot by this revision. However, this was a local effect as the water surface 300 feet upstream from the bridge was approximately the same as it was without the solid truss.

d. Model test measurements. Results of the model test program utilized in the design of the final selected plan are summarized in the following paragraphs.

(1) Water surface data. Water surface profiles were determined for the most critical design conditions, namely: (a) 75,000 cfs in the Naugatuck River, 145,000 cfs concurrent flow in the Housatonic River and an abnormal tide in Long Island Sound resulting in a tailwater elevation of 26.0 feet msl for design of protection along the Naugatuck River, and (b) 198,500 cfs in the Housatonic River, 21,500 cfs concurrent flow in the Naugatuck River and a tailwater of 26.0 feet msl for the design of protection along the Housatonic River. Water surface measurements made in the model for both the Housatonic and Naugatuck Rivers for the above conditions are tabulated in tables 3-I and 3-II and shown on plates 1 through 5.

(2) Velocity data. Velocity measurements made at critical locations throughout the model in the Derby project area are tabulated in tables 3-III and 3-IV and shown on plates 1 through 5. All velocity measurements were made during the most critical design condition producing maximum velocities, that being the discharges described in the preceding paragraph, but with a normal tide in Long Island Sound resulting in a tailwater elevation of 24.0 feet msl. These velocity measurements, made at a depth of 2 feet above the channel bottom were used as a guide along with the computed average velocities, in the design of stone channel riprap protection.

4. HYDRAULIC ANALYSES

a. General. The hydraulics of floodflows in the Housatonic River downstream of Route 8 and in the Naugatuck River downstream of Route 34 are governed by the tailwater condition at the confluence of the two rivers, which in turn is dependent on concurrent flows in the rivers and

TABLE 3-I

DESIGN WATER SURFACE ELEVATIONS - HOUSATONIC RIVER

Discharge - 198,500 cfs in Housatonic
21,500 cfs in Naugatuck
Tailwater Elevation - 26.0 msl

LEFT BANK

East Coordinate	North Coordinate	Water Surface Elevation
507,500	175,880	26.8
507,354	176,000	26.9
507,240	176,250	28.6
507,098	176,500	28.2
506,935	176,750	31.0
506,660	177,000	30.5
506,533	177,095	30.0
506,418	177,243	29.0

RIGHT BANK

East Coordinate	North Coordinate	Water Surface Elevation
506,930	175,500	27.7
506,620	176,000	29.2
506,320	176,500	29.0
506,120	176,750	29.0

TABLE 3-II

DESIGN WATER SURFACE ELEVATIONS - NAUGATUCK RIVER

Discharge - 75,000 cfs in Naugatuck
145,000 cfs in Housatonic
Tailwater Elevation - 26.0 msl

LEFT BANK

East Coordinate	North Coordinate	Water Surface Elevation
509,000	180,500	28.5
508,973	180,000	28.5
509,000	179,500	28.3
508,982	179,000	28.4
509,966	178,500	28.2
508,977	178,000	28.2
508,878	177,500	28.1
508,879	177,100	27.9
508,962	177,000	27.0
509,062	176,500	27.0
509,075	176,000	26.7
509,480	175,500	26.0

RIGHT BANK

East Coordinate	North Coordinate	Water Surface Elevation
508,632	180,500	29.1
508,660	180,000	27.9
508,594	179,500	28.0
508,586	179,000	28.0
508,570	178,500	28.0
508,565	178,000	27.8
508,478	177,500	28.0
508,270	177,000	27.0
507,976	176,500	27.0
507,790	176,000	26.6

TABLE 3-III

FLOW VELOCITIES - TWO FEET ABOVE BOTTOM SURFACE - HOUSATONIC RIVER

Discharge - 198,500 cfs in Housatonic
21,500 cfs in Naugatuck
Tailwater Elevation - 24.0 msl

East Coordinate	North Coordinate	Velocity (ft/sec)
507,800	175,000	10.3
507,500	175,200	10.3
507,410	175,250	14.0
507,330	175,400	11.8
507,480	175,610	15.5
507,520	175,770	12.4
507,300	176,000	14.0
507,250	176,200	5.8
506,910	176,530	17.5
506,740	176,540	20.5
506,590	176,550	17.5
506,415	176,560	15.7
506,770	176,850	6.8

TABLE 3-IV

FLOW VELOCITIES - TWO FEET ABOVE BOTTOM SURFACE - NAUGATUCK RIVER

Discharge - 75,000 cfs in Naugatuck
145,000 cfs in Housatonic
Tailwater Elevation - 24.0 msl

East Coordinate	North Coordinate	Velocity (ft/sec)
508,660	180,160	8.7
508,810	180,160	11.8
508,490	177,335	3.8
508,700	177,310	9.6
508,810	177,300	7.9
508,560	177,090	11.1
508,650	177,060	12.4
508,760	177,020	9.6
508,400	176,870	0.0
508,640	176,820	8.7
508,875	176,800	0.0
508,625	176,310	8.7
508,820	176,170	6.8
508,900	176,030	5.5
508,740	175,930	3.8
508,835	175,750	7.9
508,935	175,730	5.5
508,565	175,430	3.8

tide conditions in Long Island Sound. The design tailwater elevation at the confluence has been previously discussed. During flood periods this tailwater is sufficiently high to maintain low flow velocities and a relatively flat water surface throughout the area below these two bridges.

Upstream of Routes 34 and 8 to the upstream limits of the Derby project the hydraulics of floodflows in both rivers is still influenced by the downstream tailwater but technically would be classified as "gradually varied flow" with bridge and friction losses reflected in the water surface profiles.

b. Design water surface profiles. The design water surface profiles shown on plates 2 through 5 were derived from the model study measurements and by conventional backwater methods as outlined in EM 1110-2-1909 using a Manning's roughness coefficient of 0.035 and other appropriate losses. The design profiles are for a tailwater of 26.0 feet msl at the confluence and the respective design flood for each river.

c. Freeboard design. Height of protection was established generally to provide 3 feet of freeboard above the design water surface profiles. The minimum freeboard adopted was 2.6 feet at station 14400 on the Housatonic dike, based on a local water surface measurement made in the model study. This was at a downstream location on the Housatonic where velocities were relatively low and water surface a function primarily of the tailwater condition at the confluence.

d. Top elevations for dikes and walls. The design elevations for top of dikes and walls are shown on plates 2 through 5. The protection measures along the Housatonic River will be built to the following elevations:

(1) From upstream end of project (Bridge Street) to NYNH&H railroad bridge - level at elevation 34.0 feet msl.

(2) Housatonic railroad gate - elevation 34.0 feet msl.

(3) From railroad gate structure to point 600 feet downstream (start of tieback dike) - uniformly sloped from elevation 32.0 msl to 30.0 feet msl.

(4) Remainder of Housatonic dike - level at elevation 30.0 feet msl.

Top of dike along the Naugatuck River will slope uniformly from elevation 31.5 feet msl at the upstream end of the project to elevation 31.0 feet msl at the Route 34 embankment. Protection along the highway embankment and the railroad gates under Routes 8 and 34 will be built to elevation 30 feet msl.

e. Velocities of flow. Average velocities in the Housatonic River in the reach above Route 8 for the design discharge of 198,500 cfs vary from 10 to 12 fps. Maximum localized velocity measurements in the model study ranged as high as 20 fps around piers of the NYNH&H railroad bridge.

Average velocities in the reach of the Naugatuck River above Route 34 for the design discharge of 75,000 cfs vary from 8 to 10 fps. A maximum localized velocity of 11.8 fps was measured in the model at the upstream end of the Derby protective works and maximum velocity measured in the vicinity of Route 34 bridge was 12.4 fps. Average velocities in the "tidal backwater pool" downstream of Routes 8 and 34 generally were less than 5 fps.

f. Channel improvement. No improvement in the existing river channels will be made except immediately upstream of the Route 34 bridge where a land protrusion into the river on the right bank will be excavated as shown on plate 4.

g. Bridge crossings. Two highway and two railroad river crossings exist within the Derby project area. Routes 34 and 8 highway bridges are high, wide span structures and pose little restriction to the standard project floodflows. Both railroad bridges will be submerged 7 to 8 feet during the standard project flood. The railroad bridge across the Naugatuck River is within the "tidal backwater pool" area and due to its long length of overflow section is a minor hydraulic restriction to the design floods. In contrast, the railroad bridge over the Housatonic has a relatively short overflow section which includes a debris collecting trestle. Therefore, though this bridge is submerged, the major portion of floodflows pass beneath the bridge. This bridge will produce a 2 to 3 foot head loss during the standard project flood.

5. DESIGN OF STONE RIPRAP SLOPE PROTECTION

a. General. The riverward slopes of dikes, earthfills along the floodwall downstream of Bridge Street bridge and the south end slope of the Route 8 embankment will be protected with a layer of stone riprap protection placed over a layer of gravel bedding. The Derby protective works will not appreciably change the hydraulics of flow of the river channels and no riprap protection is required at locations other than described above. Allowance for scour at the toes of the above described slopes is made by extending the depth of the protection.

The design of riprap protection was based on the "tractive force" theory using procedures set forth in the draft report titled, "Criteria for Graded Stone Riprap Channel Protection," dated 20 April 1966. The requirements for bedding material and shape characteristics of stones will be in accordance with revisions made orally by representatives of OCE.

b. Design criteria.

(1) Tractive force. The average boundary shear or tractive force at a river cross section is defined by DuBoy's law:

$$\bar{\tau}_o = \gamma \; YRS$$

where $\bar{\tau}_o$ = Average unit boundary shear

γ = Unit weight of water

R = Hydraulic radius

S = Slope of energy gradient

The local unit shear or maximum tractive force at specific locations in the cross section was determined by substituting depth of flow times the cosine of the side slope ($y \cos \phi$) for the hydraulic radius in the above equation (Chow, "Open Channel Hydraulics," McGraw-Hill, 1959, p. 176).

(2) Tractive force vs. stone size. The stability of stone riprap against movement by tractive force is related, in the above referenced draft report, to the equivalent diameter of the 50 percent by weight finer stones designated D_{50} min. The relation developed between permissible tractive force and stone riprap on a horizontal surface is as follows:

$$\tau_{PL} = 0.04 \; (\gamma_s - \gamma) \; D_{50} \text{ min}$$

where τ_{PL} = Permissible tractive force on a horizontal surface

γ_s = Unit weight of stone

γ = Unit weight of water

D_{50} min = Equivalent spherical diameter of stone 50 percent by weight finer in the riprap layer

Because stone riprap has less natural stability on a slope, the permissible boundary shear on channel side slopes is less than on a horizontal surface and is determined by the following equation:

$$\tau_{PS} = \tau_{PL} \left(1 - \frac{\sin^2 \phi}{\sin^2 \theta}\right)^{0.5}$$

where τ_{PS} = Permissible boundary shear on channel side slopes

ϕ = Angle of side slope with horizontal

θ = Angle of repose of the riprap, suggested value for stone riprap, 40°

Substituting the local tractive force equation for permissible shear in the above equation and solving for D_{50} min, assuming unit weight of stone and water 165 and 62.4 lbs. per cubic foot, respectively, the following equation is derived:

$$D_{50}\ \text{min} = 15.2\ YS \left(1 - \frac{\sin^2\phi}{\sin^2\theta}\right)^{-0.5} \cos\phi$$

The use of this equation was simplified by the New England Division by developing the graphical solution shown on plate 7.

c. Channel sections. Representative cross sections were developed for each reach having similar flow characteristics. The maximum local unit boundary shear in the section, which occurs at the toe of the side slope, was used in the design of the stone riprap for the entire slope. The representative cross sections used in the analyses and the computed D_{50} min's are shown on plates 8 through 10.

d. Depth of flow and slope of energy gradient. The depth of flow "Y" at the representative cross sections was determined by averaging the difference between channel invert and design water surface throughout each reach. The slope of energy gradient for each reach was determined from the design velocity and hydraulic radius of the section, using Manning's equation and a roughness coefficient "n" of 0.035. The depth of flow and slopes of energy gradients are shown on plates 8 through 10.

e. Size and layer thickness of stone protection. In the design of stone riprap for the Derby project it was considered desirable to specify the same classes of stone protection, to the extent possible, as used for the Ansonia-Derby project since the contractor or stone supplier may be the same for both projects.

The dike slope along the Housatonic River will be protected using the Ansonia-Derby project's class II stone protection which is suitable for a D_{50} min of 0.9 foot. Protection on the slope of the dike along the Naugatuck River will require a D_{50} min of 0.5 foot, therefore, the Ansonia-Derby project's class I stone protection is specified. Class III stone protection selected as suitable for the fill along the floodwall extending downstream from Bridge Street for a distance of about 350 feet, requiring a D_{50} min of 1.1 feet, is similar to Ansonia-Derby project class IIA except the gradation has been adjusted so that it is compatible for gravel bedding, therefore no stone bedding will be required. Considering water conditions in this reach, it is believed more practical to require a suitable graded stone protection material in lieu of placing a layer of stone bedding material. The three classes of stone riprap to be used in the Derby project are shown in table 3-V.

f. Stone protection toe depths. The riprap and gravel bedding layers will extend below the final earth grade at the toe of the slope along all reaches of stone protection. The criteria in the OCE draft report referred to in paragraph 5a require that layers of stone protection extend

TABLE 3-V

CLASSES OF STONE RIPRAP

Class	Basic Layer Thickness* (inches)	Stone Weight (lbs)	Percent by Weight (SSD) Finer	D_{50} Min. (feet)
I	12	90 (Max)	100	0.55
		Between 15- 25	50	
		Less than 10	15	
		4 (Min)	0	
II	21	450 (Max)	100	0.87
		Between 60- 135	50	
		Less than 40	15	
		15 (Min)	0	
III	27	1000 (Max)	100	1.1
		Between 110- 300	50	
		Less than 40	15	
		4 (Min)	0	

* Thickness above normal high tide elevation. Where materials must be placed in water, thicknesses vary as shown on plate 6.

below any probable depths of scour. Since these probable scour depths are indeterminate for this project, depths of protection were selected on the basis of engineering judgment after careful consideration of all pertinent known and probable future conditions. The selected riprap toe treatments are shown on plate 6. Classes I and II stone protection will generally extend 5 feet below the final earth grades at the toe of the protected slopes except for a reach of approximately 500 feet along the Naugatuck River where the toe of the slope is within the present river channel area. In this reach, the class I stone protection will generally extend 1 to 2 feet below the existing channel bottom grade at the toe of the protected slope. Except for two very minor reaches, the existing channel bottom grade in the area, within 20 feet of the stone protection, is at or above elevation of the bottom of the stone protection.

Class III stone protection along the floodwall extending downstream from Bridge Street bridge for a distance of about 350 feet will extend down to elevation minus 9 msl which is about 7 feet below the existing bottom grade of the river channel. This reach is critical because tractive forces are high, Bridge Street bridge (a multiple arch bridge) could cause increased scour during flood periods, and failure of the stone protection could result in undermining and complete failure of the floodwall. Due to water conditions, it is considered advisable to limit the depth of toe protection construction to elevation minus 9 msl. In lieu of extending the construction below this elevation, the cross section of the stone protection will be a trapezoidal section as shown on plate 6. A steel sheet pile bulkhead wall will be provided near the Bridge Street bridge where construction of the rock toe is impractical.

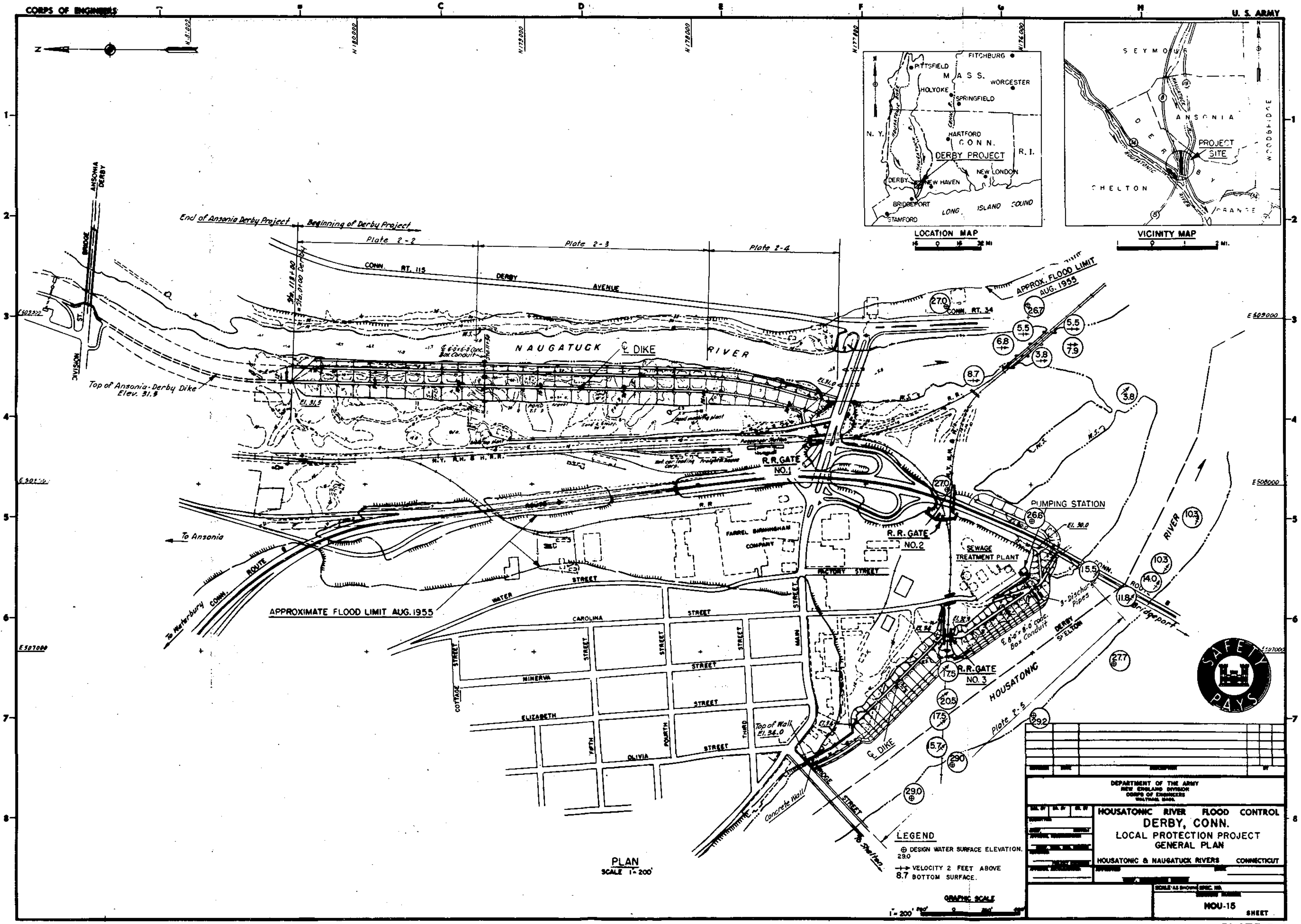
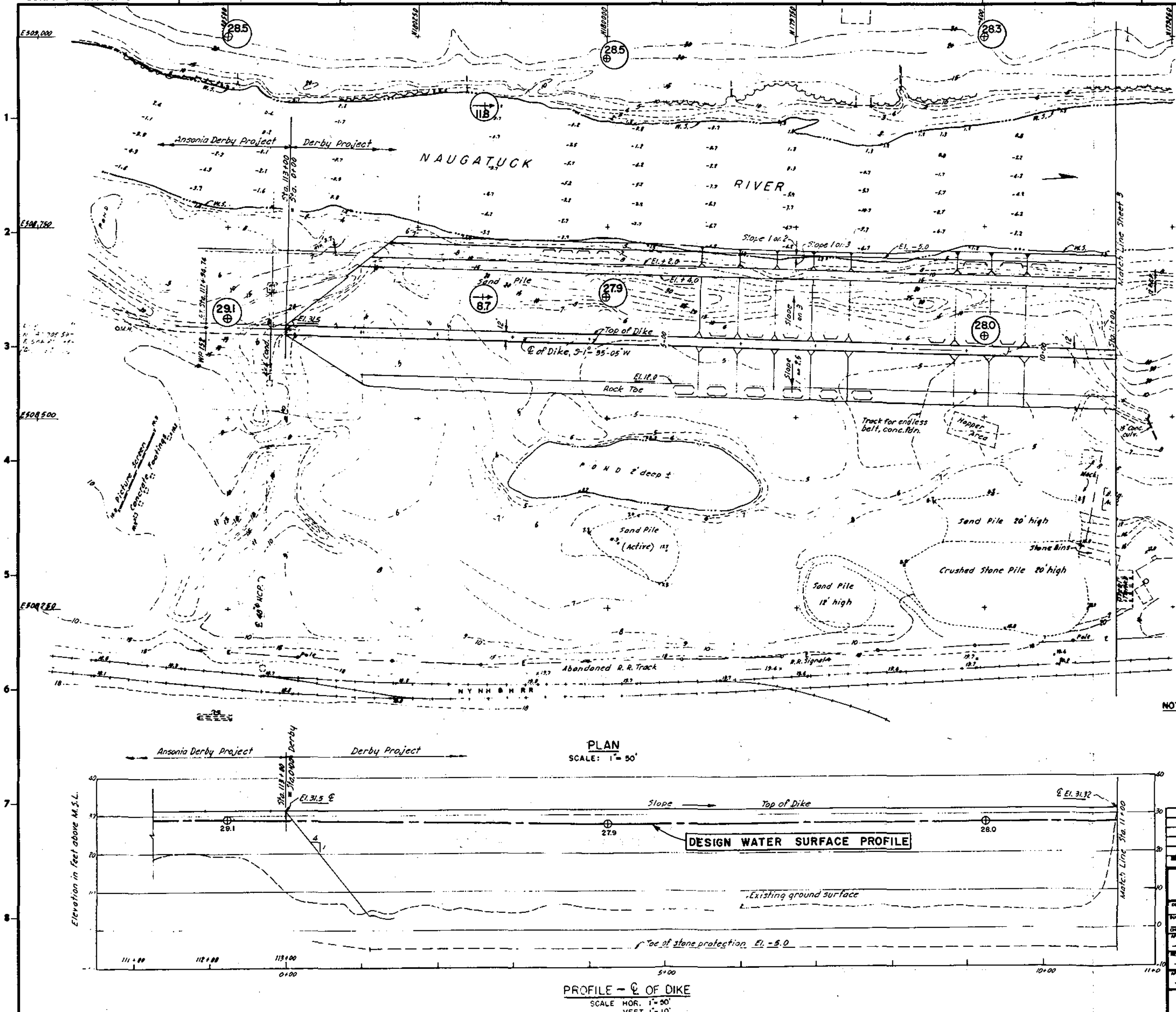

CORPS OF ENGINEERS
U. S. ARMY
LOCATION MAP
VICINITY MAP
PLAN
SCALE 1" = 200'
End of Ansonia Derby Project
Beginning of Derby Project
Top of Ansonia-Derby Dike Elev. 31.5
NAUGATUCK RIVER
℄ DIKE
R.R. GATE NO. 1
R.R. GATE NO. 2
R.R. GATE NO. 3
PUMPING STATION
SEWAGE TREATMENT PLANT
APPROXIMATE FLOOD LIMIT AUG. 1955
APPROX. FLOOD LIMIT AUG. 1955
HOUSATONIC RIVER
LEGEND
⊕ DESIGN WATER SURFACE ELEVATION.
29.0
→ VELOCITY 2 FEET ABOVE
8.7 BOTTOM SURFACE.
GRAPHIC SCALE
SAFETY PAYS
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
DERBY, CONN.
LOCAL PROTECTION PROJECT
GENERAL PLAN
HOUSATONIC & NAUGATUCK RIVERS CONNECTICUT
HOU-15

PLATE 3-1

CORPS OF ENGINEERS

U. S. ARMY



NOTES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
DERBY, CONN.
LOCAL PROTECTION PROJECT
PLAN AND PROFILE NO. 1

HOUSATONIC & NAUGATUCK RIVERS CONNECTICUT

SCALE AS SHOWN

HOU-15

SHEET

PLATE 3-2

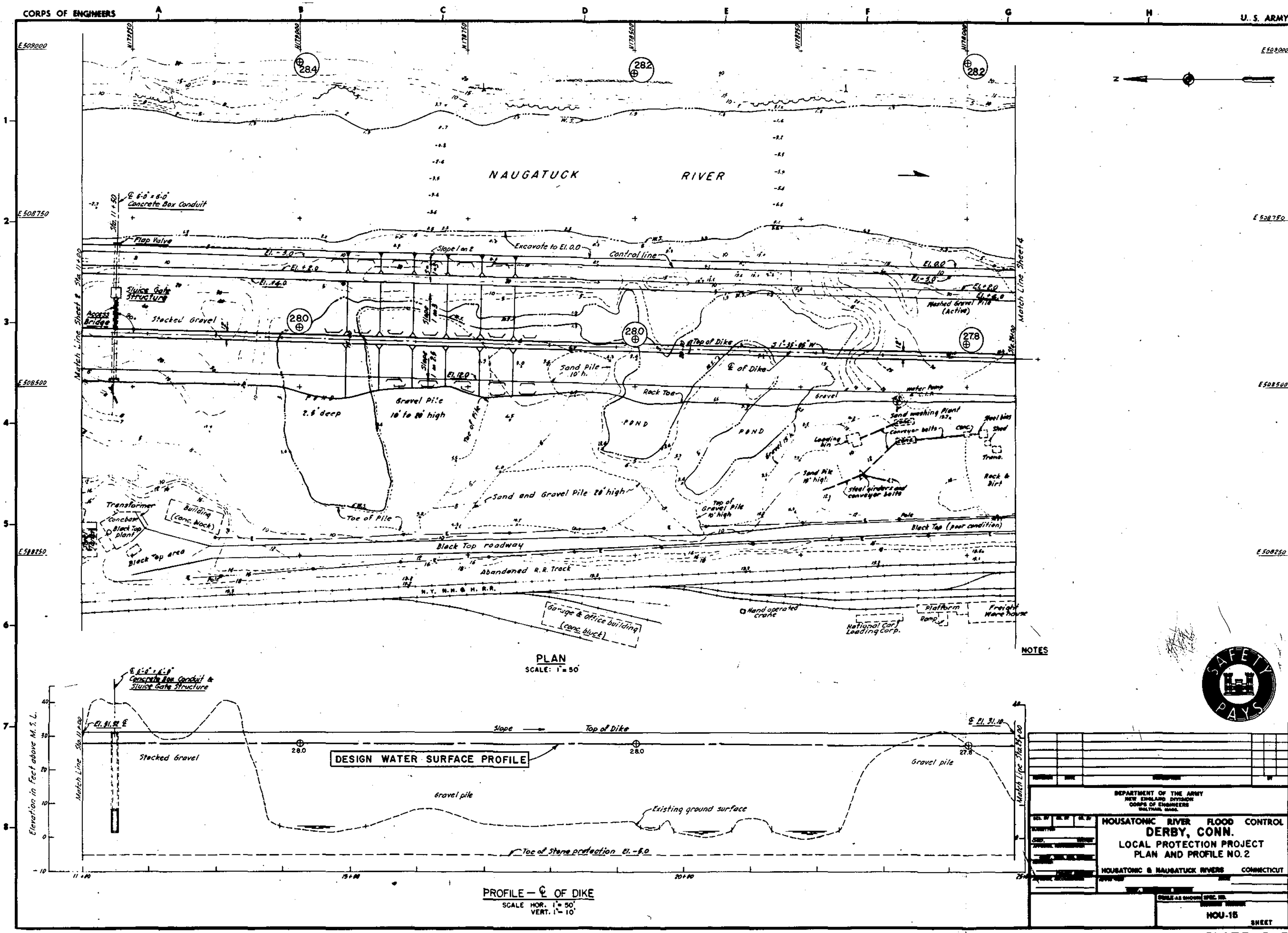
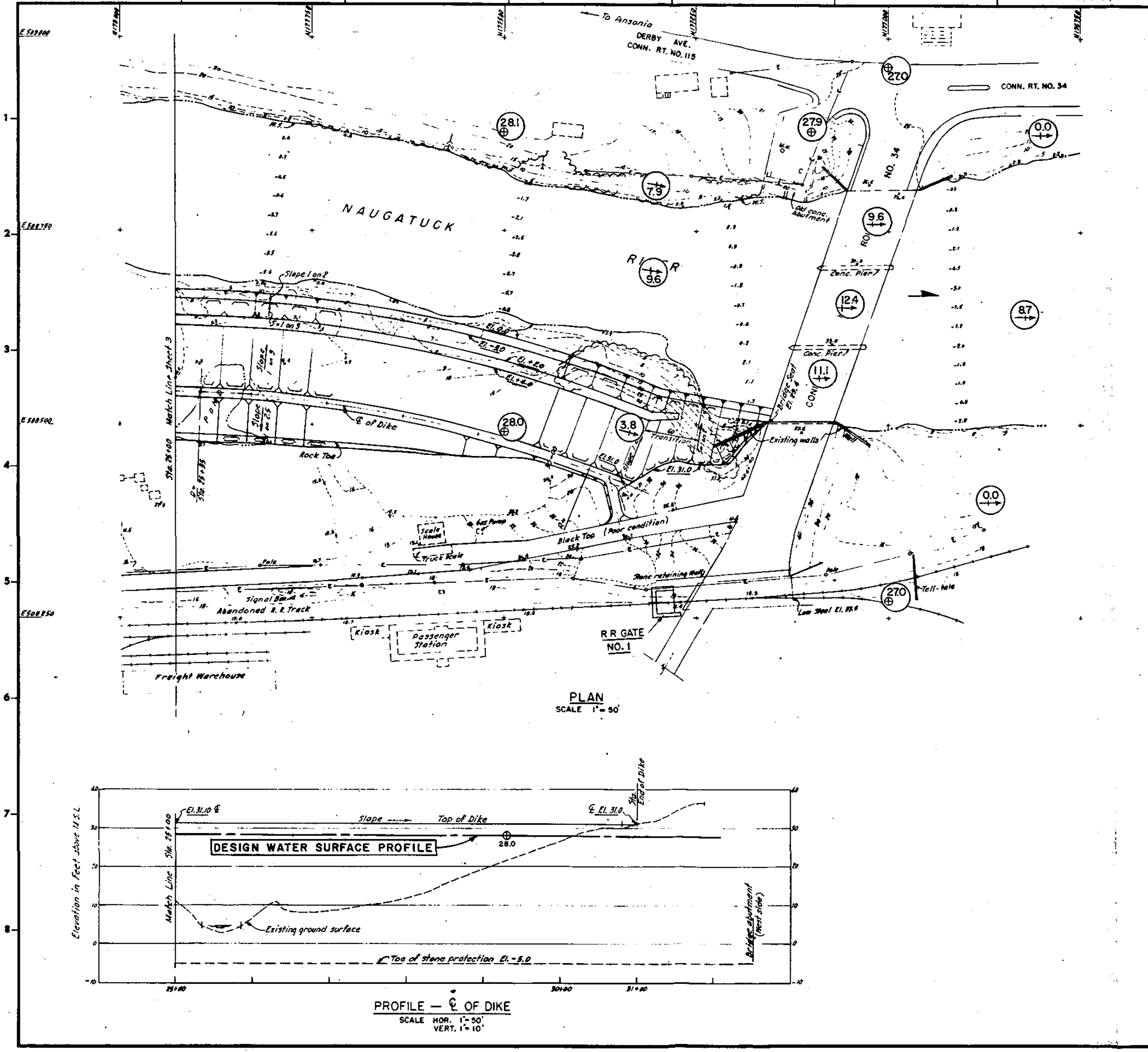

CORPS OF ENGINEERS
U. S. ARMY
NAUGATUCK RIVER
℄ 6'-0" x 6'-0" Concrete Box Conduit
Flap Valve
Sluice Gate Structure
Access Bridge
Match Line, Sheet 2 Sta. 11+00
Stacked Gravel
Excavate to El. 0.0
Control line
Slope 1 on 2
Top of Dike
℄ of Dike
Sand Pile 10' h.
Rock Toe
Gravel
Washed Gravel Pile (Active)
Match Line, Sheet 4
POND
2.5' deep
Gravel Pile 10' to 20' high
Toe of Pile
Sand and Gravel Pile 20' high
Top of Gravel Pile 10' high
Sand washing Plant
Conveyor belts
Loading bin
Steel bins
Shed
Rock & Dirt
Sand Pile 10' high
Steel girders and conveyor belts
Transformer
Building (Conc. block)
Black Top plant
Black Top area
Black Top roadway
Black Top (poor condition)
Abandoned R.R. Track
N. Y. N. H. & H. R.R.
Garage & office building (conc. block)
Hand operated crane
National Car Loading Corp.
Platform
Ramp
Freight Ware house
NOTES
PLAN
SCALE: 1" = 50'
℄ 6'-0" x 6'-0" Concrete Box Conduit & Sluice Gate Structure
Elevation in Feet above M.S.L.
El. 31.92
Slope
Top of Dike
℄ El. 31.10
DESIGN WATER SURFACE PROFILE
Stacked Gravel
Gravel pile
Existing ground surface
Toe of Stone protection El. -5.0
PROFILE — ℄ OF DIKE
SCALE HOR. 1" = 50'
VERT. 1" = 10'
SAFETY PAYS
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
HOUSATONIC RIVER FLOOD CONTROL
DERBY, CONN.
LOCAL PROTECTION PROJECT
PLAN AND PROFILE NO. 2
HOUSATONIC & NAUGATUCK RIVERS
CONNECTICUT
HOU-15

PLATE 3-3

CORPS OF ENGINEERS

U. S. ARMY



NOTES

DEPARTMENT OF THE ARMY
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HOUSATONIC RIVER FLOOD CONTROL
DERBY, CONN.
LOCAL PROTECTION PROJECT
PLAN AND PROFILE NO. 3

HOUSATONIC & NAUGATUCK RIVERS CONNECTICUT

SCALE: AS SHOWN

HOU-15

SHEET

PLATE 3-4

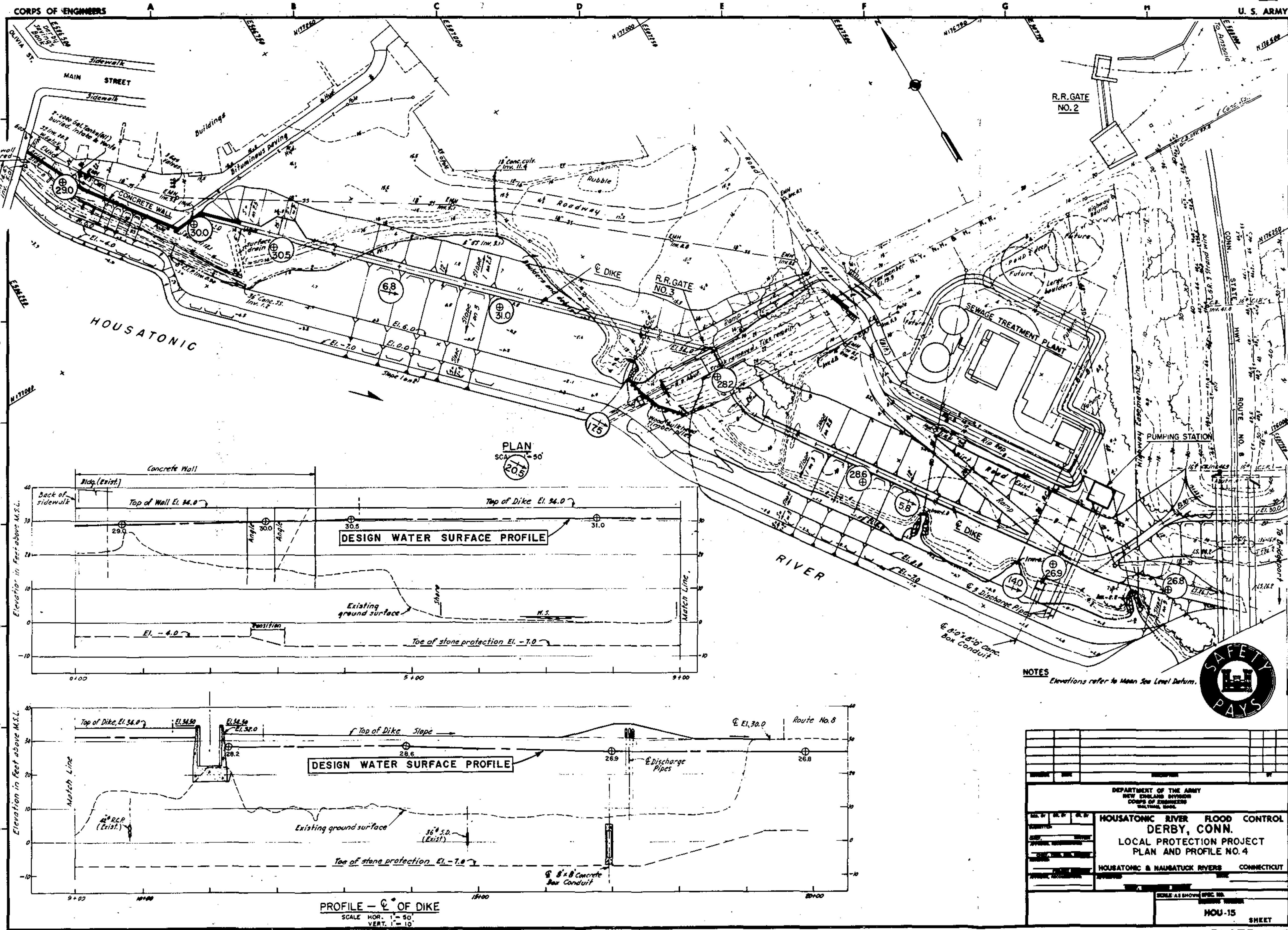
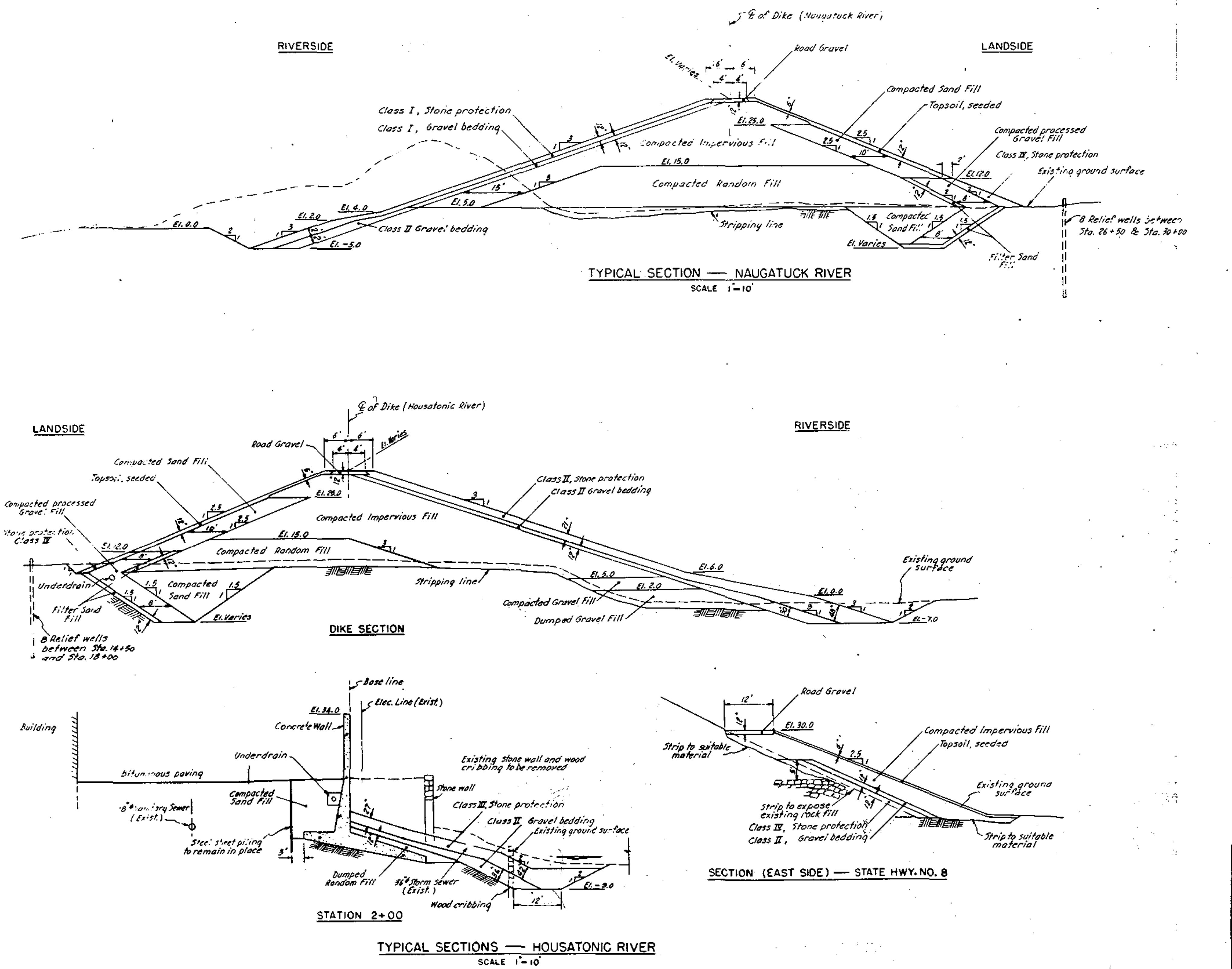

CORPS OF ENGINEERS
U. S. ARMY
MAIN STREET
Sidewalk
Buildings
Bituminous paving
CONCRETE WALL
Roadway
Rubble
R.R. GATE
NO. 2
R.R. GATE
NO. 3
℄ DIKE
HOUSATONIC
RIVER
SEWAGE TREATMENT PLANT
PUMPING STATION
Ramp
Rip Rap
CONN. STATE HWY. ROUTE NO. 8
To Shelton
To Bridgeport
℄ 8'x8' Conc. Box Conduit
℄ 3 Discharge Pipes
PLAN
SCALE 1" = 50'
NOTES
Elevations refer to Mean Sea Level Datum.
SAFETY PAYS
Concrete Wall
Bldg. (Exist.)
Back of sidewalk
Top of Wall El. 34.0
Top of Dike El. 34.0
DESIGN WATER SURFACE PROFILE
Existing ground surface
Toe of stone protection El. -7.0
Match Line
Elevation in Feet above M.S.L.
Top of Dike El. 34.0
El. 32.0
Top of Dike
Slope
℄ El. 30.0
Route No. 8
℄ Discharge Pipes
42" R.C.P. (Exist.)
36" S.D. (Exist.)
℄ 8'x8' Concrete Box Conduit
PROFILE - ℄ OF DIKE
SCALE HOR. 1" = 50'
VERT. 1" = 10'
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
HOUSATONIC RIVER FLOOD CONTROL
DERBY, CONN.
LOCAL PROTECTION PROJECT
PLAN AND PROFILE NO. 4
HOUSATONIC & NAUGATUCK RIVERS
CONNECTICUT
HOU-15

PLATE 3-5

CORPS OF ENGINEERS U. S. ARMY



REVISION	DATE	DESCRIPTION	BY

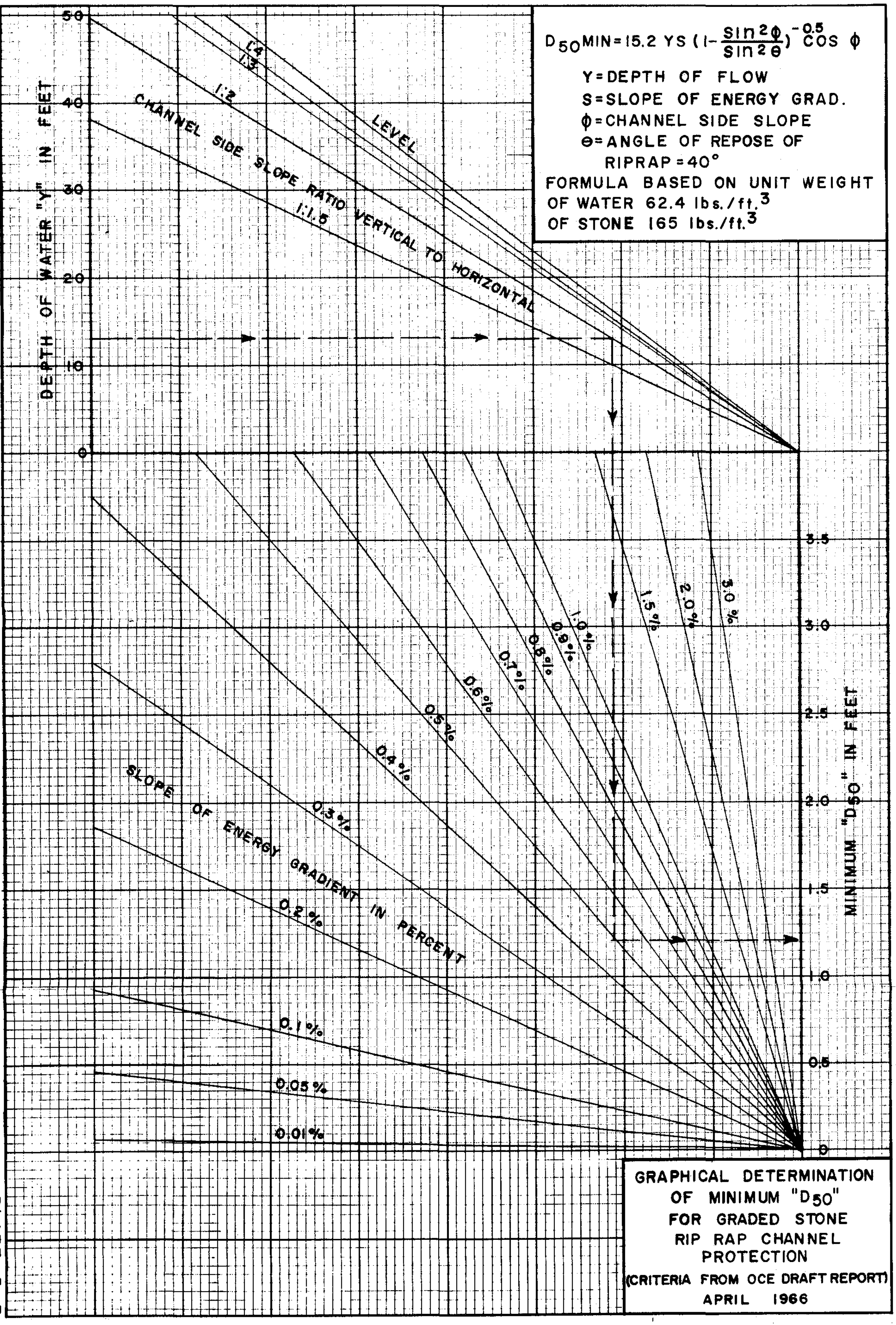
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
DERBY, CONN.
LOCAL PROTECTION PROJECT
TYPICAL SECTIONS

HOUSATONIC & NAUGATUCK RIVERS CONNECTICUT

SCALE: AS SHOWN SPEC. NO.
DRAWING NUMBER
HOU-15
SHEET

PLATE 3-6

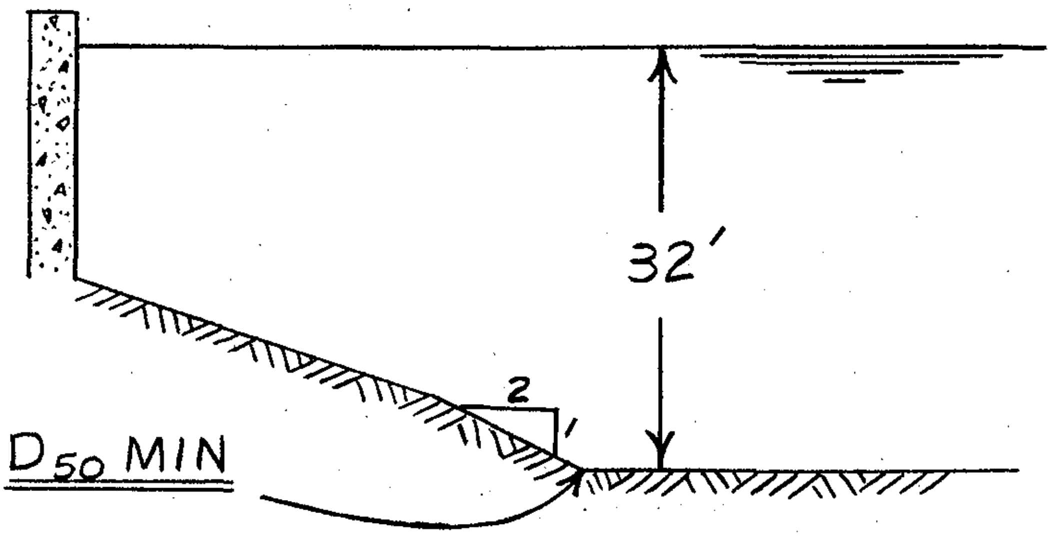


GRAPHICAL DETERMINATION OF MINIMUM "D_{50}" FOR GRADED STONE RIP RAP CHANNEL PROTECTION

(CRITERIA FROM OCE DRAFT REPORT)

APRIL 1966

HOUSATONIC RIVER
TYPICAL SECTION #1



Y = 32.0 FeeT

SIDE SLOPE = 1 ON 2

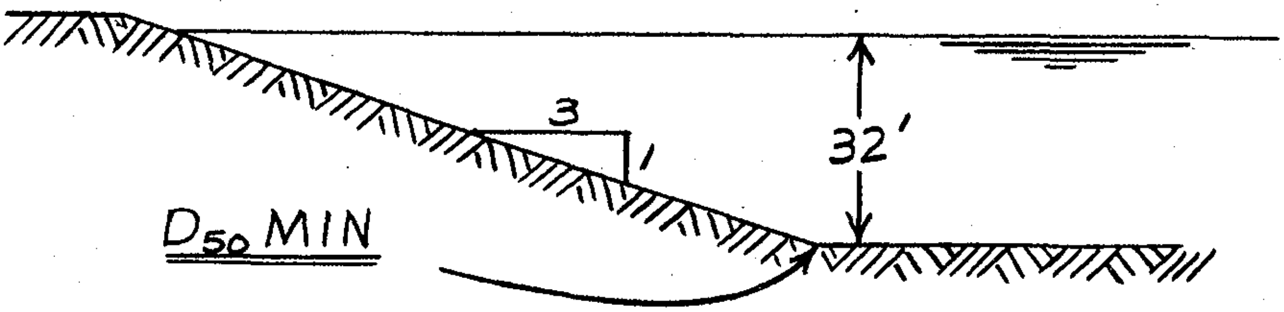
V = 17 ′/sec.

n = 0.035

S = 0.0018

D_{50} MIN = 1.1 FeeT

HOUSATONIC RIVER
TYPICAL SECTION #2



$Y = 32.0$ FeeT

SIDE SLOPE = 1 on 3

V = 17 '/sec.

$n = 0.035$

$S = 0.0018$

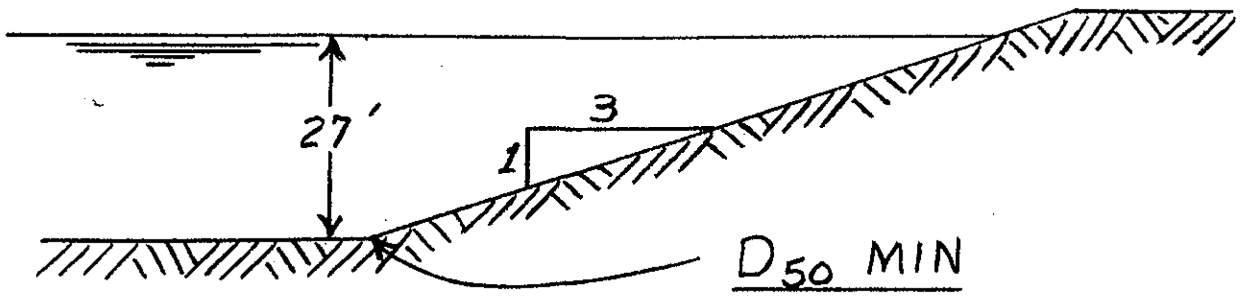
D_{50} MIN = 0.9 FeeT

SUBJECT DERBY L.P.P.

COMPUTATION STONE RIPRAP DESIGN - D_{50} MIN'S

COMPUTED BY PLM CHECKED BY DATE 11-7-67

TYPICAL SECTION NAUGATUCK RIVER



$Y = 27.0'$

SIDE SLOPE = 1 ON 3

$V = 12$ '/sec.

$n = 0.035$

$S = 0.001$

D_{50} MIN = 0.5 FecT